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Interstitial Bryozoan Fauna from Capron Shoal, Florida and adjacent areas: Final Report

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Summary

This is the final report concerning the distribution of interstitial bryozoan species on and around Capron Shoal, Florida. These bryozoans are nearly-microscopic marine invertebrates which encrust sand grains or shell fragments. The intent of this study was to determine whether species of bryozoans previously only recorded for Capron Shoals are found elsewhere. The present report centers around a technical publication (Winston and Håkansson 1986) describing the bryozoan fauna at Capron Shoal which included descriptions of twelve new species. The possibility that one or more of the species were not found elsewhere raised the concern that use of Capron Shoal as a borrow area for a beach nourishment project would pose a potential threat to these species. In response to this concern, the Jacksonville District sponsored this project.

Samples were collected from Capron Shoal and an unnamed shoal (Shoal "A") during July 2000 (which served as the basis of a pilot study) and Capron Shoal and four other nearby shoals in July 2001. Sorting, identification, and curation were done according to publications and oral advice by Dr. Winston of the Virginia Museum of Natural History. These procedures involved working with dry specimens probably precluding identification of two "target" (new) and one "non-target" (previously described) species.

All ten of the new species described in Winston and Håkansson (1986) which could be expected to be found based on the sampling techniques were found at Capron Shoal. Nine of these species were found elsewhere. All of the expected non-target species were also found. Interestingly, two of the non-target species were found only at Capron Shoal and six species were found at the other shoals but not at Capron. At both sites, the target species constituted less than 6% of the total bryozoan count.

The implication of the one target species found only at Capron Shoal is moot. In the pilot study, it was determined that in order to find all of the species in any particular sample or group of samples, 6 liters of material would need to be examined. Since available resources allowed for sorting of only 3 liters of material from all sites combined, the absence of the species in question may be due to insufficient sampling. Further, analyses herein suggest that with examination of additional material, more species would be found. However, with the data at hand, that the distribution of this one species is indeed limited to Capron Shoal cannot be ruled out. Sufficient material has been archived to distinguish between these alternatives.

Introduction

Winston and Håkansson (1986) reported on a unique assemblage of thirty-three sand encrusting bryozoans which included new species and genera ("target species") (Table 1) at Capron Shoal, Florida. These bryozoans are apparently adapted to a high wave-energy habitat, previously thought to be unable to support such a fauna, and characterized by a small size and the characteristics of simplified colony structure and very early reproduction.

While some of the bryozoan species in the Capron Shoal fauna have relatively broad geographic distributions, there have been no additional distributional data for the new species since they were described. Further, while interstitial organisms have been well studied in intertidal sand and mud habitats, considerably less work has been done on the ecology and taxonomy of the interstitial fauna of subtidal, high wave energy habitats, and particularly interstitial organisms which are encrusting rather than free-living. Winston (1982) did an exhaustive study of the bryozoan fauna of the Indian River area of Florida (including Ft. Pierce) and found none of the new species later described and only a few species of the more widely distributed ones from Capron Shoal. Thus, there is no scientific basis to predict the extent of the distribution of the new species reported by Winston and Håkansson (1986).

The approach used in this study consisted of two phases. The first was a pilot study at Capron and another nearby Shoal. The results and conclusions from the pilot study were used to develop a sampling strategy for a second phase that could reasonably be expected to either confirm the presence of any or all of Winston and Håkansson (1986)'s new species (target species), or to suggest that their distribution was probably limed to Capron Shoal. This report synthesizes data from both phases to address the issue at hand.

Table 1. Capron Shoals interstitial bryozoan fauna (after Winston and Håkansson [1986]).

Reported as unique to Capron Shoals	**Reported as more widely distributed**
Alcyonidium capronae	*Aimulosia pusilla*
Bartensia minuata	*Aimulosia uvulifera*
Cleidochasma angustum	*Alderina smitti*
Cribrilaria parva	*Antropora leucocypha*
Cymulopora uniserialis	*Beania klugei*
Disporella plumosa	*Bellulophora bellula*
Drepanophora torquata	*Cleidochasma porcellanum*
Hippothoa balanophila	*Cribrilaria innominata*
Membranipora triangularis	*Cupuladria doma*
Phylactella ais	*Discoporella umbellata ssp. depressa*
Reginella repangulata	*Escharina pesanseris*
Trematooecia psammophila	*Floridina parvicella*
	Membranipora arborescens
	Membranipora savartii
	Microporella umbracula
	Parasmitina nitida
	Parasmitina signata
	Schizoporella rugosa
	Spathipora brevicauda
	Retevirgula caribbea
	Trypostega venusta
	Vibracellina laxibasis

Methods

Collection Phase 1 samples were collected from Capron Shoals at several areas, including the location where Winston and Håkansson (1986) made their collections (buoy 10A) as well as from Shoal A (Table 2A, Figure 1). Collection was made using a modified mini-Peterson grab aboard Florida Atlantic University's R/V Oceaneer on July 25, 2000. Remote video-camera monitoring confirmed that the samples were taken consistent with normal operation of the device. Fourteen samples were collected from Capron Shoal and five from Shoal A. Five samples from each location were worked up. Additionally, two archived core samples from preliminary geotechnical investigations were obtained from Jacksonville District and sorted in an attempt to determine whether they could provide useful data.

Phase 2 samples were collected on July 31, 2001, from two locations each at Capron Shoal and each of two shoals north and south of Capron Shoal (Shoal A, B, St. Lucie Shoal, and Pierce Shoal)(Table 2B, Figure 1). Collection was made by Scuba (strictly adhering to USACE protocols) on July 31, 2001. At each of the ten sites, three 2-liter samples were taken. Sub-samples of approximately 200 ml from two of the three samples at each site were worked up.

Samples were collected from high points of each of the shoals as determined by preliminary reconnaissance work. Collections made by divers were from the coarsest-appearing material within visual range. Material was placed in cloth soil sample bags and transported to the laboratory in ice chests.

Sample processing. Fine sediment was removed by rinsing the sample in a 0.25mm sieve. Samples were gently rinsed with freshwater and then air dried. Initial sorting was performed by the author at U.S. Army Corps of Engineers Engineer Research and Development Center (ERDC) and by the Louis Berger Group, East Orange NJ.

Identifications were performed using descriptions in Winston and Håkansson (1986) and a set of specimens identified by Dr. Winston from both material collected for the pilot study and material deposited at the Virginia Museum of Natural History. Holotype and study material deposited in the American Museum of Natural History were also examined for species for which an unambiguous identification could not otherwise be made.

Specimens which did not closely correspond to those described in Winston and Håkansson (1986) were recorded as 'unknown.' A small number of bryozoans from each sample was also too abraded or otherwise damaged to provide unambiguous characteristics for identification and were recorded as 'too abraded for i.d.' Identifications were performed using a Leica Wild MC3 scope equipped with 25X oculars and an Intralux 4000-1 fiber optic light source. Colonies were stained to enhance contrast as required. Sample volumes screened ranged from 60-270 ml.

The trade-off for the cost-effectiveness of working with dried specimens is that three of the species reported for Capron Shoal (*Aclcyonidium capronae*, *Bartensia minuata*, and *Beania klugei*) are unlikely to be found, but it was assumed that if all other target species were found this group would likely be to occur as well.

Summary statistics were performed and graphs prepared to determine patterns of distribution and abundance. Formal inferential statistical tests were not performed because the nature of replication and low numbers would have violated basic assumptions required to make results of these tests valid.

Table 2A. Collection locations for 2000 collection. Shaded cells indicate samples for which quantitative data for species abundance are presented.

Sample	Site	Depth	lat/long	Location
1	Capron	12 m	27° 26.607' N 80° 13.321' W	Buoy 10A
2	Capron	"	'	"
3	Capron	6 m	27° 26.524' N 80° 13.686' W	(crest)
4	Capron	"	'	"
5	Capron	"	'	"
6	Capron	8 m	27° 26.528' N 80° 13.693' W	10 m from samples 3-5
7	Capron	"	'	"
8	Capron	"	'	"
9	Capron	"	27° 26.543' N 80° 13.633' W	100 m from samples 3-5
10	Capron	"	'	"
11	Capron	"	'	"
12	Capron	10 m	27° 26.016' N 80° 13.758' W	1000 m from samples 3-5
13	Capron	"	'	"
14	Capron	"	'	"
15	Shoal A	10 m	27° 29.607' N 80° 16.409' W	
16	Shoal A	"	'	
17	Shoal A	"	'	
18	Shoal A	"	27° 29.611' N 80° 16.410' W	10 m from samples 15-17
19	Shoal A	"	'	"
C-23	Capron	8 m	---	Archived core
C-28	Capron	9 m	---	"

Table 2B. Locations for 2001 collection (see also Figure 1). Collections were made by divers with the exception of sample #100 (indicated by 'grab').

Sample	Location	Lat/long	Depth (ft.)
100	St. Lucie Shoal (grab)	27^0 18.560' N 80^0 08.995' W	20
101	Shoal A 1 of 2	27^0 29.452' 80^0 16.451'	28
102	Shoal A 1 of 2	27^0 29.452' 80^0 16.451'	28
103	Shoal A 1 of 2	27^0 29.452' 80^0 16.451'	28
104	Shoal A 2 of 2	27^0 30.242' 80^0 16.249'	25
105	Shoal A 2 of 2	27^0 30.242' 80^0 16.249'	25
106	Shoal A 2 of 2	27^0 30.242' 80^0 16.249'	25
107	Shoal B 1 of 2	27^0 31.590' 80^0 16.335'	28
108	Shoal B 1 of 2	27^0 31.590' 80^0 16.335'	28
109	Shoal B 1 of 2	27^0 31.590' 80^0 16.335'	28
110	Shoal B 2 of 2	27^0 32.110' 80^0 26.295'	27
111	Shoal B 2 of 2	27^0 32.110' 80^0 26.295'	27
112	Shoal B 2 of 2	27^0 32.110' 80^0 26.295'	27
113	Capron Shoal 1 of 2	27^0 26.669' 80^0.13.621'	20
114	Capron Shoal 1 of 2	27^0 26.669' 80^0 13.621'	20
115	Capron Shoal 1 of 2	27^0 26.669' 80^0 13.621'	20
116	Capron Shoal 2 of 2	27^0 24.760' 80^0 13.808'	25
117	Capron Shoal 2 of 2	27^0 24.760' 80^0 13.808'	25
118	Capron Shoal 2 of 2	27^0 24.760' 80^0 13.808'	25
119	Pierce Shoal 1 of 2	27^0 22.188' 80^0 12.442'	25
120	Pierce Shoal 1 of 2	27^0 22.188' 80^0 12.442'	25
121	Pierce Shoal 1 of 2	27^0 22.188' 80^0 12.442'	25
122	Pierce Shoal 2 of 2	27^0 21.403' 80^0 12.462'	24
123	Pierce Shoal 2 of 2	27^0 21.403' 80^0 12.462'	24
124	Pierce Shoal 2 of 2	27^0 21.403' 80^0 12.462'	24
125	Saint Lucie Shoal 1 of 2	27^0 18.560' 80^0 09.033'	24
126	Saint Lucie Shoal 1 of 2	27^0 18.560' 80^0 09.033'	24
127	Saint Lucie Shoal 1 of 2	27^0 18.560' 80^0 09.033'	24
128	Saint Lucie Shoal 2 of 2	27^0 18.560' 80^0 09.017'	19
129	Saint Lucie Shoal 2 of 2	27^0 18.560' 80^0 09.017'	19
130	Saint Lucie Shoal 2 of 2	27^0 18.560' 80^0 09.017'	19

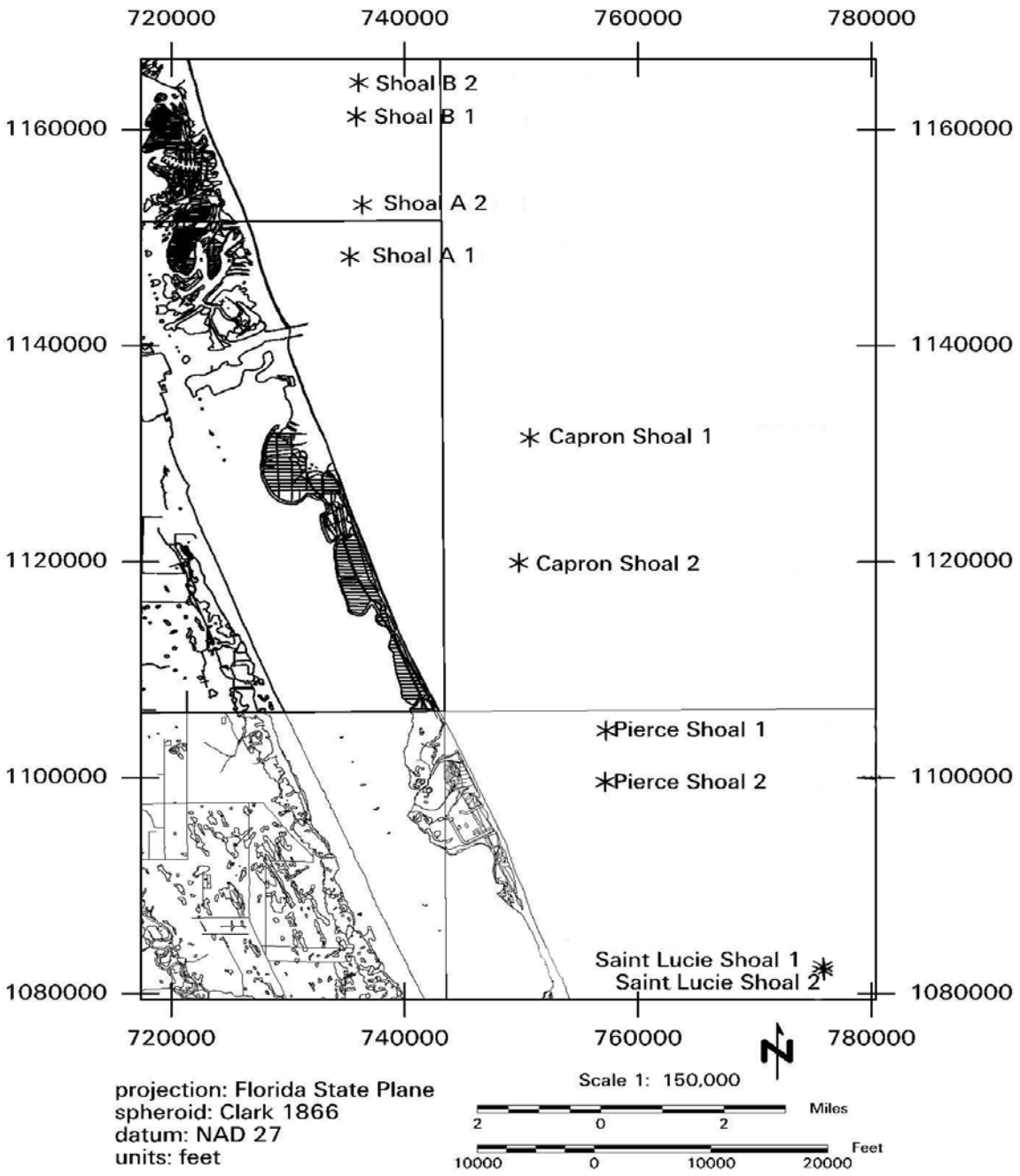

Figure 1. Location of collection sites for 2001 sampling.

Results

Summary statistics are found in Tables 3 and 4 and Figures 2 A-D. Thirty-one of the thirty-four species reported in Winston and Håkansson (1986) were found, including ten of the twelve target species. The two target species not encountered, *Bartensia minuata* and *Alcyonidum capronae*, are typically found attached to another bryozoan, *Cupuladria*; the former were not expected to be found in dried collections because of its growth form. One non-target species, *Beania clugei*, also was not found because of its growth form.

In composite samples comprising 2000 and 2001 collections (Table 3C), while all ten of the expected target species were found at Capron Shoal, only nine were found elsewhere; two *Cymulopora* were found at Capron Shoal but none were found elsewhere. Of the non-target species, four *Cleidochasma* and one *Schizoporella* were also encounered at Capron Shoal but absent elsewhere. Interestingly, several species which were not found at Capron Shoal were found elsewhere (*Aimulosia uvulifera*, *Antropora leucophya*, *Escharina pesanseris*, *Membranipora savartii*, *Microporella umbracula*, and *Retevirgula caribbea*). In this case, numbers involving presence were less than fifteen. Inconsistencies in presence/absence data between collection years involved species with abundance below ten. For example, the target species *Phylactella ais*, was found only at Capron Shoal in 2000, but only elsewhere in 2001. Any species with a total abundance of twenty or higher across both years and all sites was found at all sites and in both years.

Abundance of the target species was very low compared to many of the other species, constituting some 4.3% and 5.1% of the Capron and other sites total populations respectively. Of the target species with non-zero values, all were found in abundances of four or more at sites other than Capron Shoal.

The pattern of species abundance was typical of most communities, being dominated by a few species and then composed of a larger number of species of diminishing abundance (Figure 3). The pattern for Capron and the other shoals appeared similar if not identical – any difference is probably due to differences in sample size.

In a graphic plot comparing 'sampling intensity,' expressed as the number of individuals against species number (Figure 4), linear regressions of log normalized data produced better fit than exponential rise to a maximum (of the type $y = a(1-e^{-bx})$). Data for this plot were obtained by using individual and variously pooled samples constituting pseudoreplication. Although this is not statistically desirable, it was essential in order to develop the plot. Since pseudoreplicated data were used in this data exploration technique, specific regressions and tests for possible differences between sites are not presented. (This sort of data analysis is often used to estimate required sample size to obtain all of the species in a particular area and was used in the pilot study).

Although describing the pattern of variability for these samples was not an objective of this study, it is clear that spatial variability is very high. While some sets of samples collected from the same location had similar species composition or number of individuals (2000: #1 and 2; 12, 13 and 14), other similar sets did not (2000: #3,4, and 5; 6, 7, and 8). Further, many patterns appear to be the result of differing numbers of individuals available for between site comparisons resulting in different species numbers of bryozoans. Particularly with the small sample size precluding the use of inferential statistics to sort these factors out, all that can be assumed is that there is high variability. There also appeared to be no trend with depth, but this may have been confounded by low sample numbers.

An important factor in determining the abundance of many of the bryozoan species

seemed to be substratum type. Although sorting by particle size (shell hash vs. sand) was beyond the scope of this study, the high incidence of shell hash appeared to be related to the high abundance of individuals and species numbers in the St. Lucie Shoal samples. Similarly, the Shoal A collections from 2000 had a lower number of individuals than Capron Shoal which may have been related with the finer substratum there.

The samples collected in July 2000, but not examined quantitatively (#6-14), and the samples from archived cores, showed no additional target species in a non-quantitative perusal. The samples from archived cores yielded bryozoans from which identifications could be made; both targeted and non-targeted species were found.

Photographs of representative target and non-target species are presented in Plate 1. For additional material, the reader is advised to consult Winston and Håkansson (1986).

Table 3A. Number of individual bryozoans collected and summary statistics in 2000 collection. Note that number in the 'subtotal' and 'total' columns for species is cumulative and not additive.

	Capron Shoal						Shoal A					Total	
Sample	1	2	3	4	5		15	16	17	18	19		
Species						subtotal						subtotal	
Target spp.													
Alcyonidium capronae						0						0	0
Bartensia minuata						0						0	0
Cleidochasma angustum			2		3	5						0	5
Cribrilaria parva					2	2						0	2
Cymulopora uniserialis					1	1						0	1
Disporella plumosa					2	2			1	1		2	4
Drepanophora torquata			1	1	2	4		1	1			2	6
Hippothoa balanophila		1			2	3			1			1	4
Membranipora triangularis				1	5	6		4	2	1		7	13
Phylactella ais					1	1						0	1
Reginella repangulata					5	5						0	5
Trematooecia psammophila			1	4	2	7						0	7
subtotal	0	1	4	6	25	36	0	5	5	2	0	12	48
# of spp.	0	1	3	3	10	10	0	2	4	2	0	4	10
Other spp.													
Aimulosia pusilla					1	1						0	1
Aimulosia uvulifera						0						0	0
Alderina smitti			2	7	24	33	1	3	5			9	42
Antropora leucocypha						0						0	0
Beania klugei						0						0	0
Bellulophora bellula			6	7	11	24	2	1				3	27
Cleidochasma porcellanum	1		2		1	4						0	4
Cribrilaria innominata			2	1	13	16	1	2	5			8	24
Cupuladria doma	33	114	85	339	254	825	31	96	101	105	65	398	1223
Discoporella umbellata	2	3		2	2	9		1		2		3	12
Escharina pesanseris						0						0	0
Floridina parvicella					2	2						0	2
Membranipora arborescens			1			1		1				1	2
Membranipora savartii						0						0	0
Microporella umbracula						0						0	0
Parasmitina nitida	1	1		2		4			1			1	5
Parasmitina signata		1				1						0	1
Retevirgula caribbea						0	1					1	1
Schizoporella rugosa						0						0	0
Spathipora brevicauda	3	1				4						0	4
Trypostega venusta	4		5		27	36	1	1	2	1		5	41
Vibracellina laxibasis			1	12	25	38		8	8	10	6	32	70
subtotal	44	120	104	370	360	998	37	113	122	118	71	461	1459
# of spp	6	5	8	7	10	14	7	8	6	4	3	10	15
Too abraded to i.d.		5	4	2	1	12	1	2	10	1	2	16	28
unknown	1	6	6	4	25	42	1	3	12	5	1	22	64
All spp.													
Total	45	132	118	382	411	1088	39	123	149	126	74	511	1599
# of spp	6	6	11	10	20	24	6	10	10	6	3	14	25
volume sorted (ml)	60	171	92	253	270	846	73	146	185	226	155	785	1631

Table 3B. Number of individual bryozoans collected and summary statistics in 2001 collection. Sites are arranged from north to south.

Site	Shoal B 1		Shoal B 2		Shoal A 1		Shoal A 2		Capron 2		Capron 1		Pierce 2		Pierce 1		St.Lucie 1		St. Lucie 2		Total
Sample no.	107	109	111	112	101	103	104	105	117	118	113	114	122	123	119	121	125	127	128	129	
Species																					
Target spp.																					
Alcyonidium capronae																					**0**
Bartensia minuata																					**0**
Cleidochasma angustum				1													2	1			**4**
Cribrilaria parva		2								2									1	3	**8**
Cymulopora uniserialis									1												**1**
Disporella plumosa	4	10	1	1			1	1		1	2	2	4				2	2	1	2	**34**
Drepanophora torquata	6	1						1	2		2		1	1	1		3	4	5	13	**40**
Hippothoa balanophila	9	12	1	1		1				5			3			3	2			2	**39**
Membranipora triangularis	2	1	1							1	3	1	1			1	2		1	1	**15**
Phylactella ais								1					1				2	1		2	**7**
Reginella repangulata			1			1			1								2	2	1		**8**
Trematooecia psammophila	2	8	3	2		1	2		3	3	3	1	2	2	1	1	6	3	10	6	**59**
subtotal	**23**	**34**	**7**	**5**	**0**	**3**	**3**	**3**	**7**	**12**	**10**	**4**	**12**	**3**	**2**	**5**	**21**	**13**	**19**	**29**	**215**
# of spp.	5	6	5	4	0	3	2	3	4	5	4	3	6	2	2	3	8	6	6	7	10
Other spp.																					
Aimulosia pusilla																1	1		1	3	**6**
Aimulosia uvulifera		2						1											1	1	**5**
Alderina smitti	13	10	10	3	1		4	6	1	3	3	4	5	3	4	3	8	8	15	7	**111**
Antropora leucocypha	1																1				**2**
Beania klugei																					**0**
Bellulophora bellula	10	11	4	9	2	2			2	4	1	1	3			2	2	6	28	22	**109**
Cleidochasma porcellanum																					**0**
Cribrilaria innominata	14	6	3	5	1		2	1	1	1	1		2	2	1	2	3		22	4	**71**
Cupuladria doma	70	63	40	56	109	90	117	238	75	96	205	138	69	39	40	41	276	323	549	350	**2984**
Discoporella umbellata	4	4	1			1	1	1		4	1	3	2	1	5	3	3	8	7	20	**69**
Escharina pesanseris	1	2																	1	1	**5**
Floridina parvicella	2	4	2	1						1			1	1	1	1		1	6	9	**30**
Membranipora arborescens	2			1	1		1		1				1		1			1	3	2	**14**
Membranipora savartii	2																				**2**
Microporella umbracula			1	2														1	5	5	**14**
Parasmitina nitida		1					1									1				6	**9**
Parasmitina signata																			1		**1**
Retevirgula caribbea	1				1		1							1							**4**
Schizoporella rugosa										1											**1**
Spathipora brevicauda	9															2	1		3		**15**
Trypostega venusta	38	22	8	8	1	9	3		6	6		1	10	2	4	5	9	14	20	30	**196**
Vibracellina laxibasis	15		6	4	8	5	9	8	3	12	9	7	11	7	6	9	30	36	26	39	**250**
subtotal	**182**	**125**	**75**	**89**	**124**	**107**	**139**	**255**	**89**	**128**	**220**	**154**	**104**	**56**	**62**	**70**	**334**	**398**	**688**	**499**	**3898**
# of spp	14	10	9	9	8	5	9	6	7	9	6	6	9	8	8	11	10	9	15	14	**20**
Too abraded to i.d.	39		18	20	7	19	5	2	15	12	16	15	35	13	11	24	72	50	38	76	**487**
unknown	18		7	7		4		4		3	4	4	7	3	3	3	5	1	25	21	**119**
All spp.																					
Total	205	159	82	94	124	110	142	258	96	140	230	158	116	59	64	75	355	411	707	528	4113
# of spp	19	16	14	13	8	8	11	9	11	14	10	9	15	10	10	14	18	15	21	21	30
volume sorted (ml)	232	207	160	162	154	164	192	200	184	186	210	184	192	194	198	188	175	178	188	164	3712

Table 3C. Summary of data broken down by year from Tables 3A and 3B (note that species numbers are cumulative not additive).

	2000 Sampling		2001 Sampling		Composite Sample	
	Capron	non-Capron	Capron	non-Capron	Capron	non-Capron
Species						
Target spp.						
Alcyonidium capronae	0	0	0	0	0	0
Bartensia minuata	0	0	0	0	0	0
Cleidochasma angustum	5	0	0	4	5	4
Cribrilaria parva	2	0	2	6	4	6
Cymulopora uniserialis	1	0	1	0	2	0
Disporella plumosa	2	2	5	29	7	31
Drepanophora torquata	4	2	4	36	8	38
Hippothoa balanophila	3	1	5	34	8	35
Membranipora triangularis	6	7	5	10	11	17
Phylactella ais	1	0	0	7	1	7
Reginella repangulata	5	0	1	7	6	7
Trematooecia psammophila	7	0	10	49	17	49
subtotal	36	12	33	182	69	194
# of spp.	10	4	8	9	10	9
Other spp.						
Aimulosia pusilla	1	0		6	1	6
Aimulosia uvulifera	0	0		5	0	5
Alderina smitti	33	9	11	100	44	109
Antropora leucocypha	0	0		2	0	2
Beania klugei	0	0		0	0	0
Bellulophora bellula	24	3	8	101	32	104
Cleidochasma porcellanum	4	0		0	4	0
Cribrilaria innominata	16	8	3	68	19	76
Cupuladria doma	825	398	514	2470	1339	2868
Discoporella umbellata	9	3	8	61	17	64
Escharina pesanseris	0	0		5	0	5
Floridina parvicella	2	0	1	29	3	29
Membranipora arborescens	1	1	1	13	2	14
Membranipora savartii	0	0		2	0	2
Microporella umbracula	0	0		14	0	14
Parasmitina nitida	4	1		9	4	10
Parasmitina signata	1	0		1	1	1
Retevirgula caribbea	0	1		4	0	5
Schizoporella rugosa	0	0	1	0	1	0
Spathipora brevicauda	4	0		15	4	15
Trypostega venusta	36	5	13	183	49	188
Vibracellina laxibasis	38	32	31	219	69	251
subtotal	998	461	591	3307	1589	3768
# of spp	14	10	10	19	15	19
Too abraded to i.d.	12	16	58	429	70	445
unknown	42	22	11	105	53	127
All spp.						
Total	1088	511	693	4023	1781	4534
# of spp	24	14	18	28	25	28
volume sorted (ml)	846	785	764	2948	1610	3733

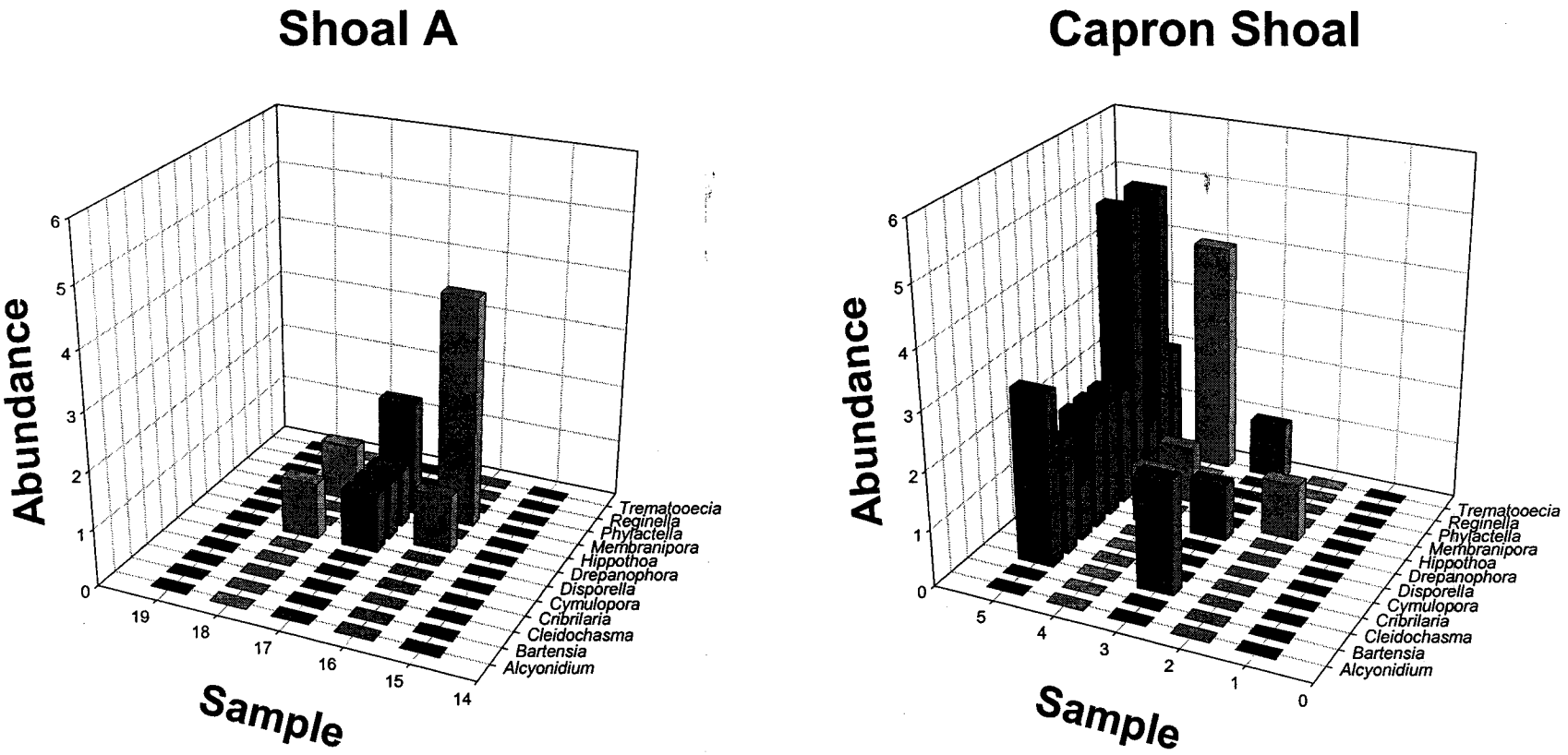

Figure 2A. Abundance of target species at Capron Shoal and Shoal A for 2001 sampling. (*Membranipora* refers to *M. triangularis*)

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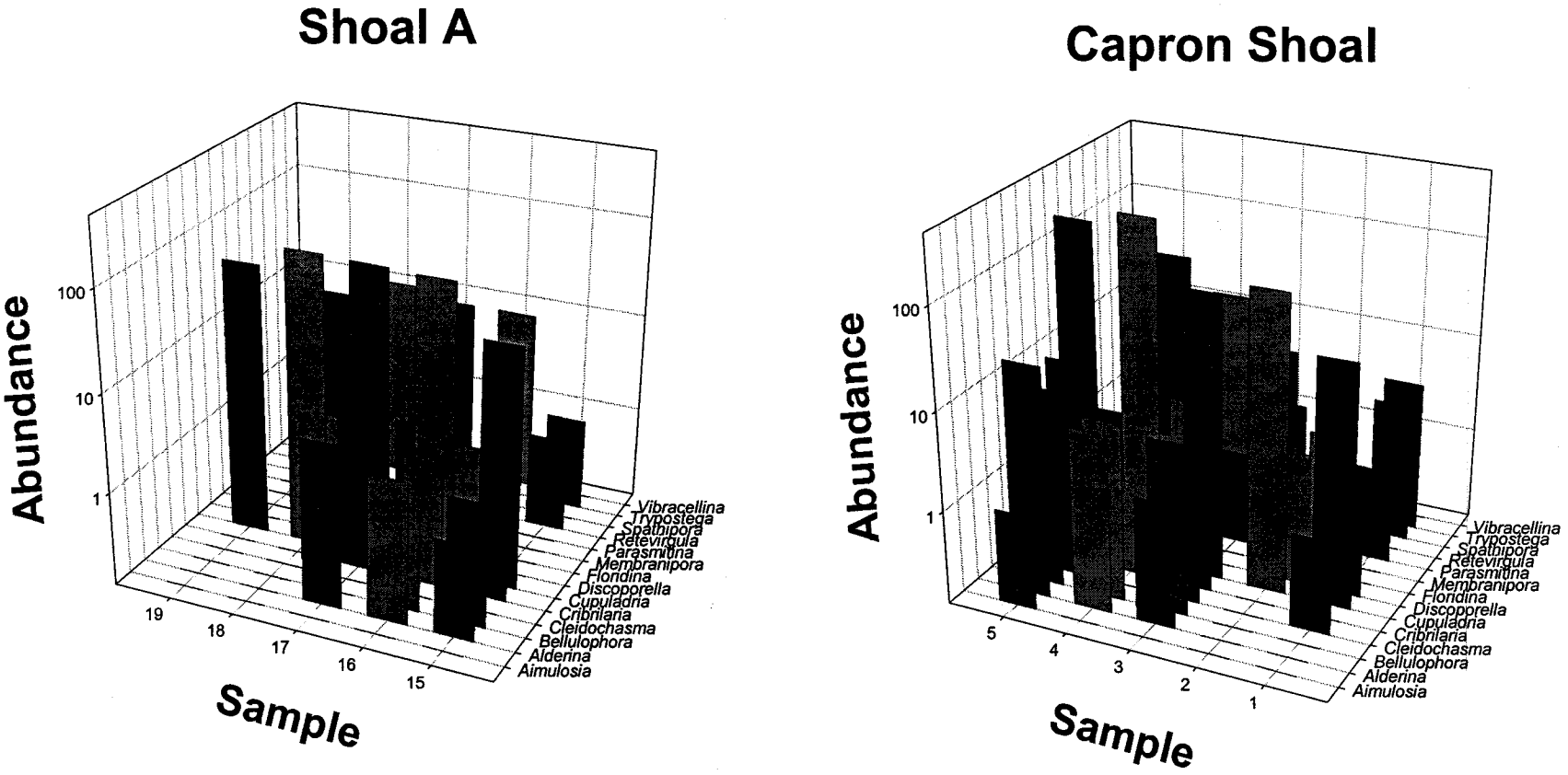

Figure 2B. Abundance of non-target species at Capron Shoal and Shoal A. Only species with non-zero data are listed. Note log scale *Membranipora* refers to *M. arborescens* for 2001 sampling. **- BOTTOM OF PAGE -**

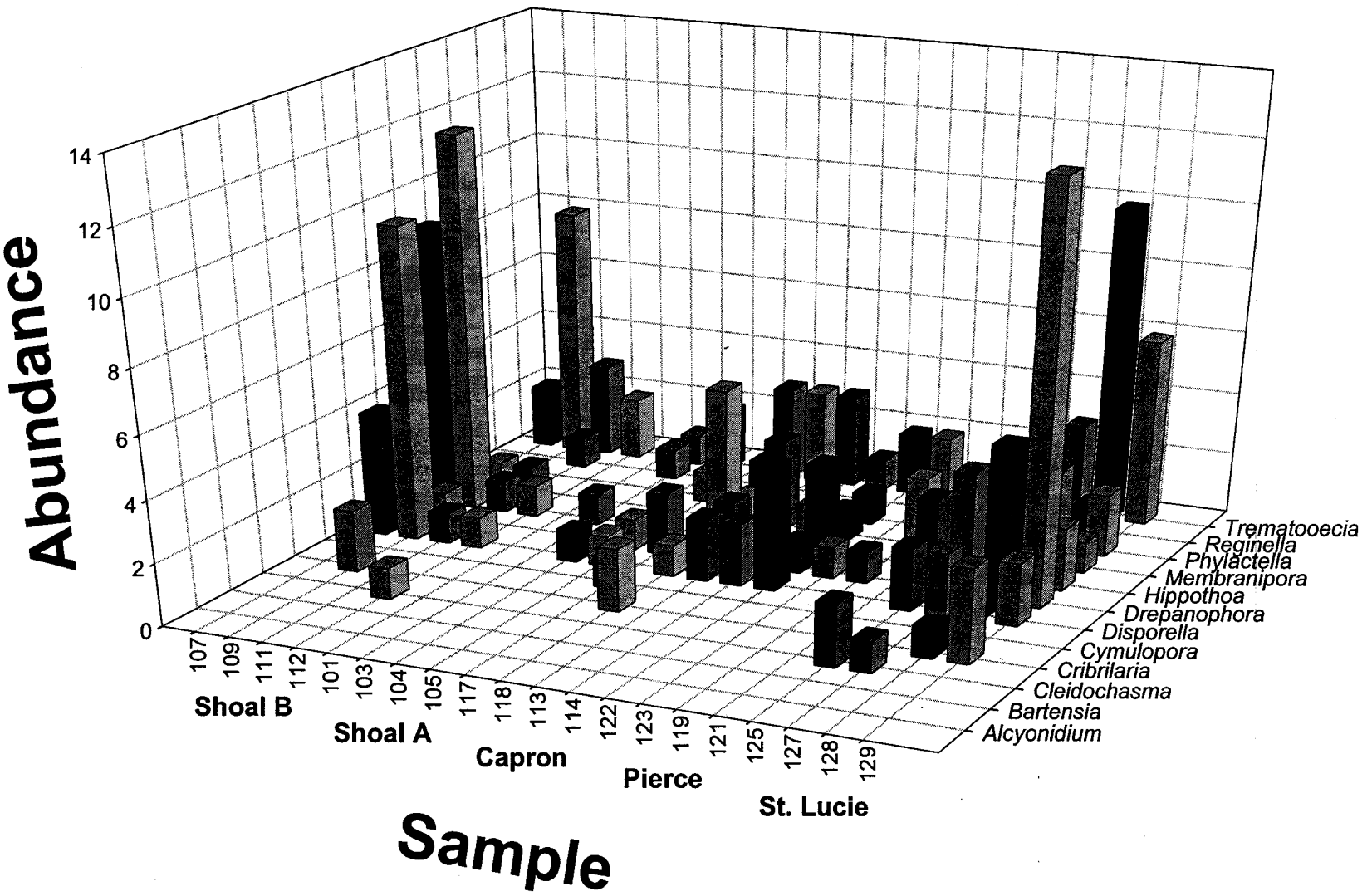

Figure 2C. Abundance of target species for 2001 collection. Sites are arranged from North (left) to South (right). The quartet of samples for each site represents two replicate collections at the pair of sampling locations for each site. - **BOTTOM OF PAGE** -

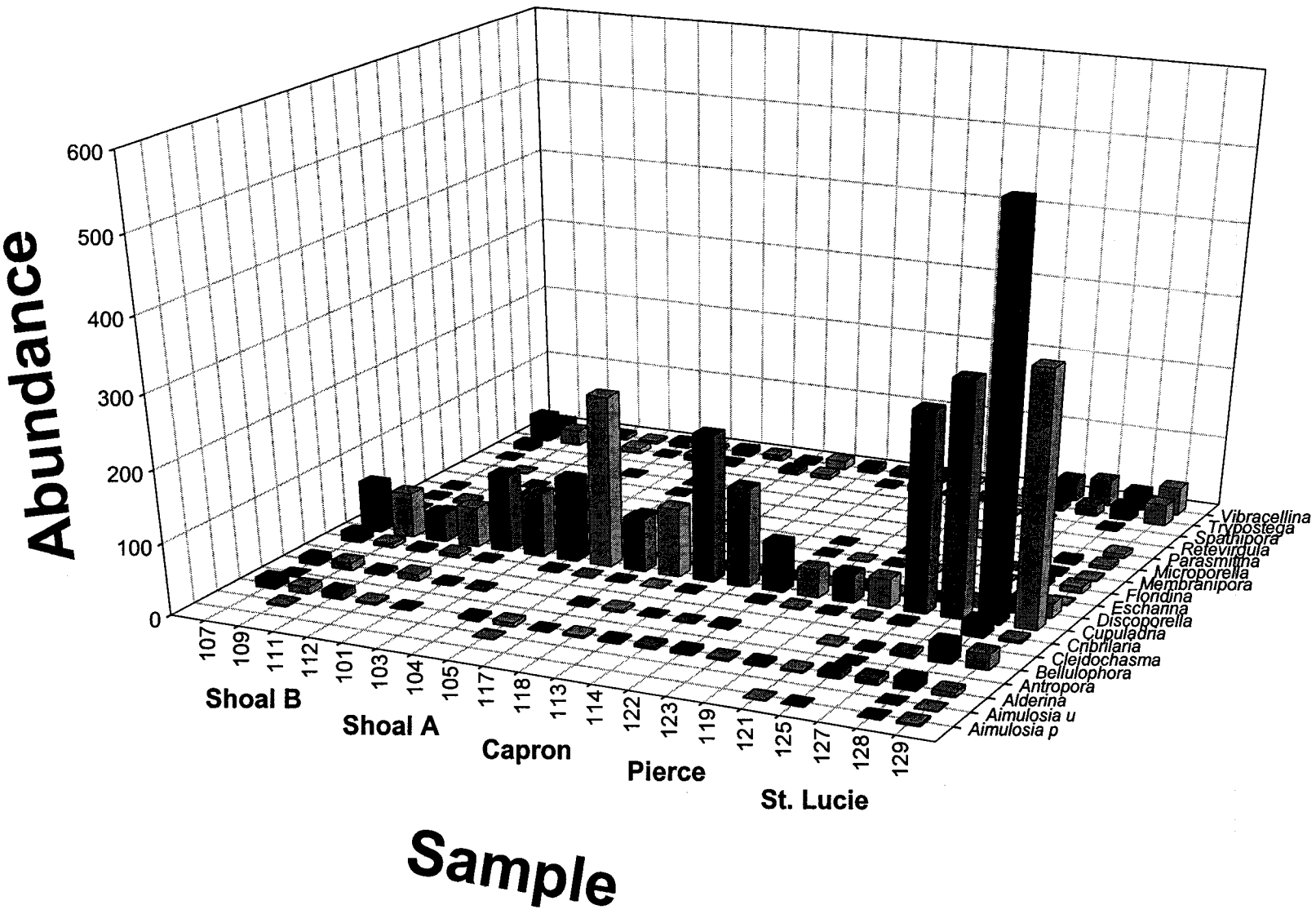

Figure 2D Abundance of non-target species for 2001 collection. Sites are arranged from North (left) to South (right). The quartet of samples for each site represents two replicate collections at the pair of sampling locations for each site. - **BOTTOM OF PAGE** -

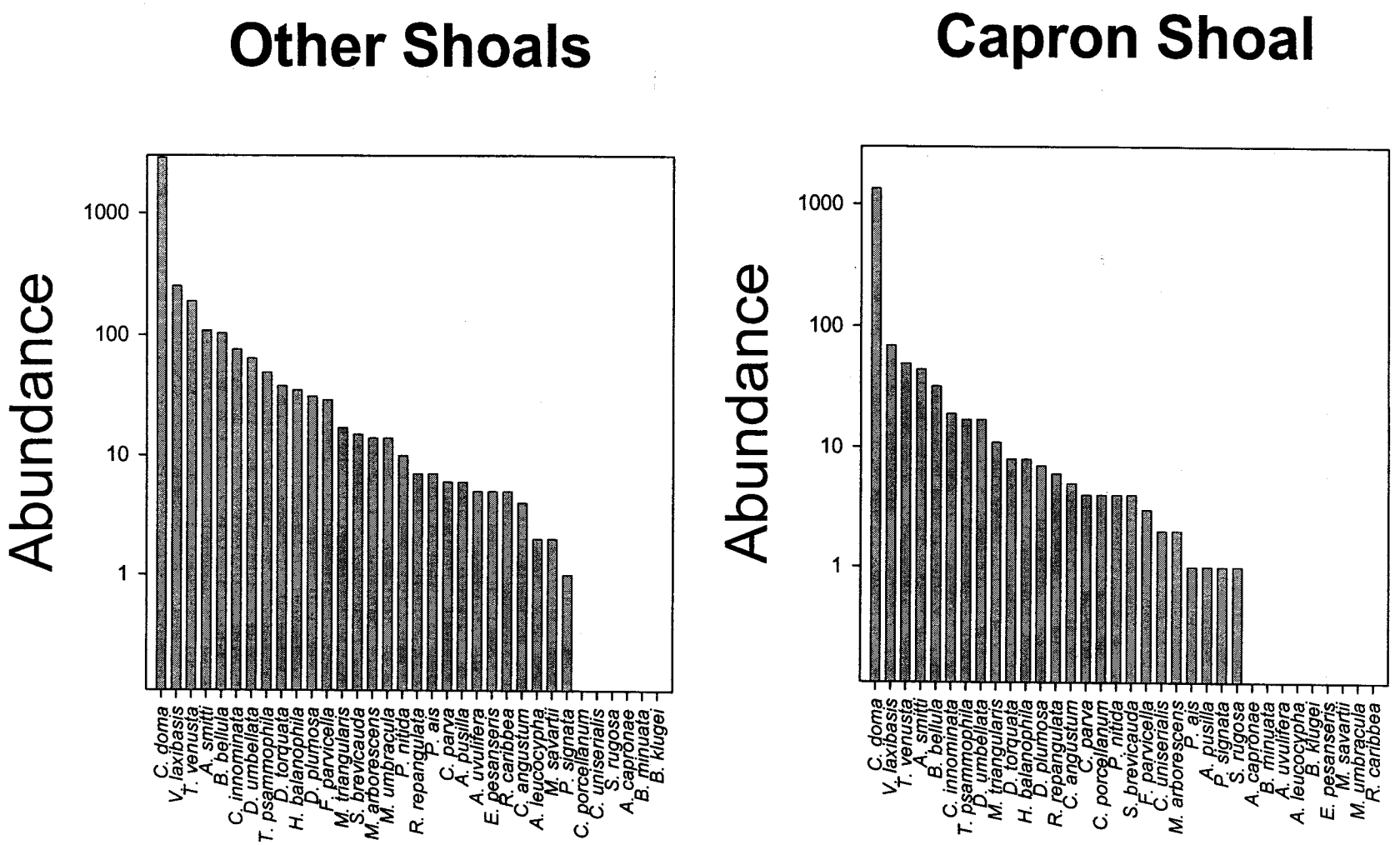

Figure 3. Species abundance plot for pooled samples (note log scale). **- BOTTOM OF PAGE -**

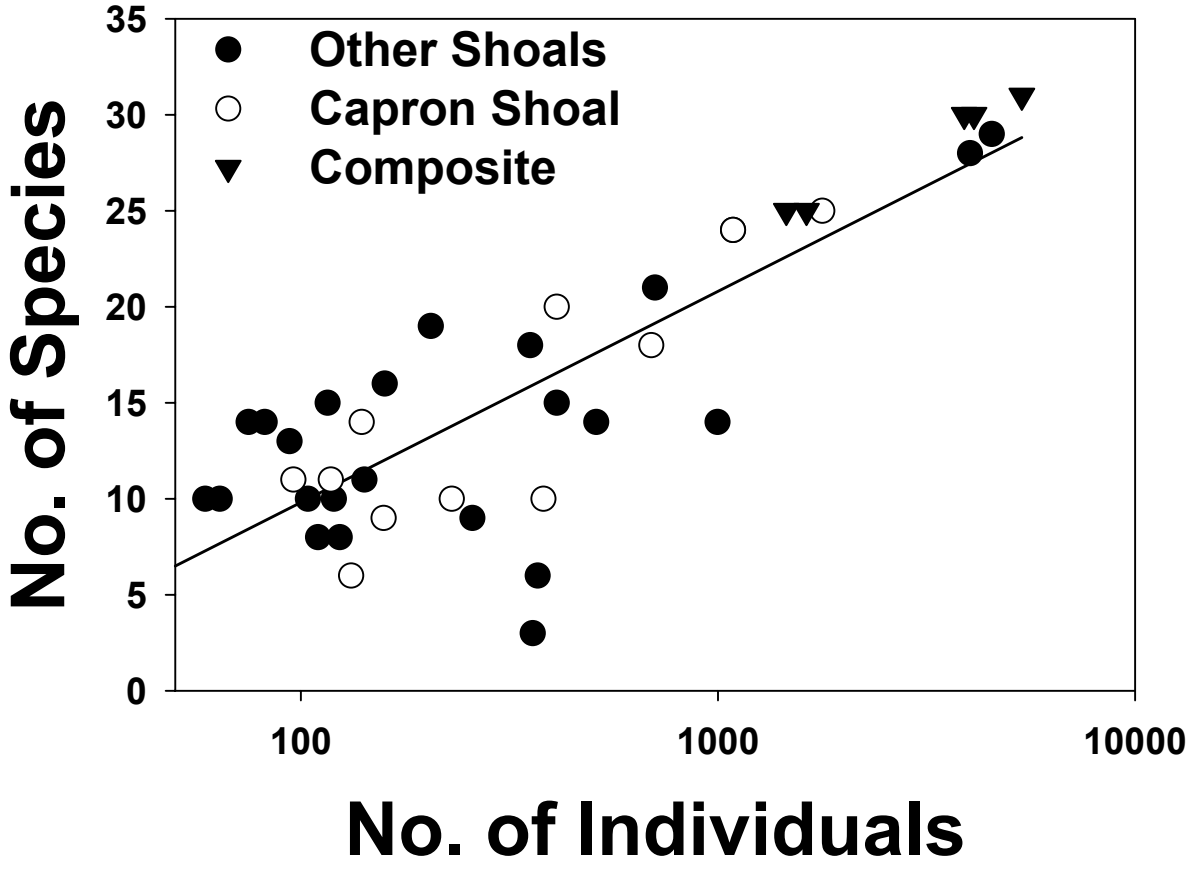

Figure 4. Association between number of total number of bryozoans and total number of species for each sample. The regression line is a linear regression of $\log_{10}$ normalized data. Site totals reflect cumulative species numbers and total volumes for each site. The project total represents pooled data for both. Note this is based on pseudoreplicated data.

Discussion

This report provides evidence that the new species reported for Capron Shoal (Winston and Håkansson 1986) are not all restricted to that location. Although the abundance of these target species was extremely low, since their abundances are of the same magnitude as the majority of the non-target species, they should be considered to have a distribution extending at least to the other shoals examined.

One species, *Cymuloplora uniserialis*, was found exclusively at Capron Shoal. Whether it will be found elsewhere is unknown since even at Capron Shoal only two individuals were found. Further, two other non-target species (*Cleidochasma porcellanum* and *Schizoporella rugosa*), showed a similar pattern with four and one individuals at Capron Shoal, respectively, and none elsewhere.

Evidence from the linear regression and limitations of sample processing suggest that additional species would be detected with increased sample size. The regression of total number of individuals against number of species (Figure 4) predicts this because it was still linear in the range of the total number of samples taken. Had this curve leveled off, this possibility would have been contraindicated. Similarly, on the basis of minimum sample size calculations made during the pilot study, examination of 6 liters of material was needed to be examined for each site in order to find all of the species. For the pilot and present study combined, only 1.6 and 3.7 l were examined for Capron and the other Shoals respectively Thus, it cannot be determined with any degree of certainty whether the absence of *Cymulopora* in samples at sites other than Capron Shoal is due to sampling intensity or those sites being outside its range of distribution.

Adequately addressing this issue would require additional sampling.

Two of the target species (*Alcyonidium* and *Bartensia*) and one of the non-target species (*Beania*) were not considered in this study because of the logistics involved in searching for them. Protocols for studying these involve an examination of live, or possibly liquid-preserved specimens.

Many of the samples contained microscopic encrusting bryozoans not described in Winston and Håkansson (1986). Whether these individuals have been described and reported for other locations or are new to science should also be considered.

Literature

Håkansson, E. and J. E. Winston. 1985. Interstitial Bryozoans: Unexpected Life Forms in a High Energy Environment. In C. Nielsen and G. P. Larwood [eds.] Bryozoa: Ordovician to Recent. Olsen & Olsen, Fredensborg, Denmark. pp 125-134.

Winston, J. E. 1982. Marine Bryozoans (Ectoprocta) of the Indian River Area (Florida). Bulletin of the American Museum of Natural History 173: Article 2, pp 100-176.

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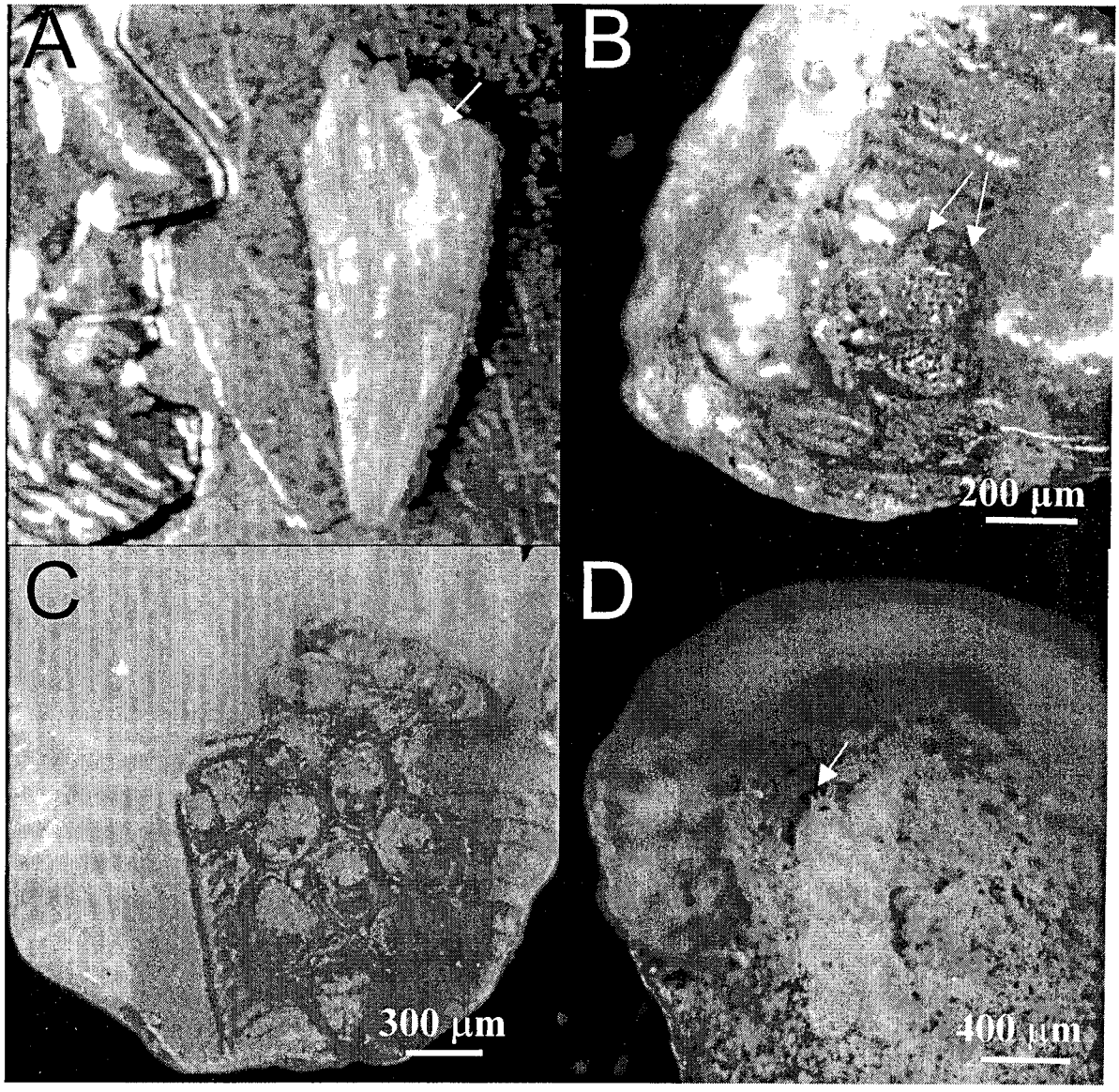

Plates. Examples of target and non-target bryozoan species. A. *Membranipora triangularis* (a target species) on shell fragment showing characteristic biserial nature and lower outer wall (arrow), note Lincoln one cent coin for size perspective. B. *Reginella repangulata* (a target species) on shell fragment. Arrows illustrate typically worn spines. C. *Floridina parvicella* (a non-target species) on shell fragment. The colony has been stained to enhance contrast. D. *Cribilaria innominata* (a non-target species) on shell fragment. Arrow illustrates characteristic quintet of spines which are usually worn.

Addendum

This section includes several questions posed by Kenneth Dugger, SAJ; and responses by Dr. William Brostoff, WES.

Thank you for your work on the bryozoans off Ft. Pierce.

There are a few questions or issues which might be addressed in the report.

Issues:
1. The report indicates one species which you found only on Capron Shoals and not at the other sites.
2. There were a couple species for which you did not sample because they must be sampled live or wet preserved to identify them.
3. The report indicates that there were not enough samples to draw a conclusion about the rarity or uniqueness of these species to Capron Shoals (especially for the species referred to in 1 and 2 above).

Questions:
1. The sampling you preformed represents what portion of the habitat (Capron Shoals, the several shoals, shoals in general along the Atlantic coast of Florida)?

The portion of the habitat we sampled was extremely small because of logistic constraints – of the many square miles that constitute Capron Shoals, we sampled at most a few square meters. From the experimental design developed in part from the Pilot Study, we determined that there is no great local spatial variation as long as the general constraints of substratum type and water clarity were met. At a larger scale, the several shoals we examined constitute a very small percentage of the Florida coastline, perhaps 5%, but your own people should be able to give you a more quantitative answer than this.

The study design I used specifically addressed the question in the lawsuit and that Dr. Winston had related to me orally as to whether the "new" species of bryozoans were found at locations other than Capron Shoal.

2. What additional effort (methods and $) would be required to sample for the two species which must be taken live or wet preserved?

Sampling the two other "target" species and the one that is known to be more widespread would involve either setting up trays of samples in (1) running seawater (perhaps at the Ft. Pierce Smithsonian Lab, or Harbor Branch), or (2) using a recirculating system at a remote location such as WES. This would involve collecting at Capron and the other Shoals and processing a large enough sample to find a few specimens of each. Either of these alternatives, including revising the report, would cost about $60K. I suspect that working with liquid preserved material would probably cost about the same, but there would also be some ground work involved in developing appropriate protocols. Keep in mind that there is no precedent for coming up with cost estimates because of the newness of these bryozoan surveys so this estimate could be off by a considerable amount.

3. What additional effort (methods, sample number/location, and $) would be required to determine whether (or not) the target species are largely limited to Capron Shoals?

One of the reasons that the settlement agreement was limited to a funding cap (and not to whatever it took to answer the question) was that we suspected that one could spend $millions (or even tens of millions) and not come up with a definitive answer.

The idea that one could spend $millions and sill not come up with a definitive answer is correct. Remember, that in science we deal with probabilities not absolutes. I don't think that the litigants in the suit are completely unreasonable, insofar as the bryozoan work.

To answer your question, I would suggest a stepwise program of increasing scale. I am not necessarily advocating any of these, but providing estimates for your planning purposes. They are based on my doing species i.d.'s and a consultant doing the initial sorting in order to make the process as quick as possible.

1) First, I would suggest working up the remaining samples from which bryozoans have been picked (about half the labor cost). There are 10 samples each from Capron Shoal 5 samples from the others. While this still wouldn't bring the total volume up to the 6 liters or so required to suggest (and this is non-quantitative) that species were absent, finding at least one specimen of the target species would be important. The rationale for working-up the material from Capron is to serve as a control, remember that there were several of the more widely distributed (non-target) species we didn't find there. The cost estimate $35K.
2) A second level of effort would be examine enough material such there is data for 6 liters each Capron and the other shoals combined. Cost estimate (in addition to above estimate): $90,000.
3) A third level of effort would be to examine material such that 6 liters was examined for two locations of each of the 5 shoals we collected from in July of this year. There is sufficient dried material to do this. The cost estimate for this is $325,000 (in addition to above estimates).
4) A fourth level of effort would be a more formal investigation of the distribution and abundance of these organisms both on Capron and on the other four shoals. It would be focused on providing quantitative spatial estimates for the number of the target species that occur on each of the shoals by examining the relationship between their abundance and (1) sediment type, (2) depth, (3) wave exposure, (4) natural patchiness. This would involve recollecting, and sampling about 200 200-ml samples per shoal. Even though this is less than the 6 liters required, with this large a sample, one could use the same sort of predictive work to estimate species occurrence as was done in the pilot and final studies. The cost estimate is ca. $2 million. Even this wouldn't provide a "definitive" answer. So, this does suggest your were right in speculating that it would cost millions of dollars for the effort.
5) Another interesting thing you might want to consider would be a smaller study of the relationship between substratum type (sand vs. shell hash) on the distribution and abundance of these critters. My understanding is that the shell hash on which these organisms are found most abundantly is not as suitable for beach nourishment as is finer sand. Assuming this is documented to be the case, the Corps could be easily "off the hook" just by saying that the areas in which they grow don't make good beaches. A project like this would of necessity be a collaborative one and probably be accomplished at a reasonable cost (it would take some time to generate a firmer cost estimate for this one but probably be between $50-100K).

In the event you are interested in any of these or other possibilities, funding could come from HQUSACE. The issue of cryptic species potentially shutting down dredging is of national

concern and not limited to Jacksonville District. Tom Patin, head of our Dredging group suggested this.

The hypothesis which I am exploring is that the discovery of these new species was not a result of their rarity but instead it was a result of the intense effort required to collect, observe, and identify them.

Rarity is something difficult to speculate on. For one species, a few thousand may not be rare but for another several million may be. This is covered in many basic Ecology textbooks. Yes, it is a grueling effort to collect and identify these critters. This task is particularly difficult since there is a decreasing number of trained taxonomists to identify special groups like this. This has been identified by organizations like the National Academy of Science as a critical problem. As you know, there are only a few people in the world who have pre-existing expertise on this group and learning to properly identify them by people like myself with a good background in related species is no easy task. Further, since there has been so little study of this group, it is likely that Dr. Winston's publication isn't the last word on the situation. In my work, I found a number of bryozoans which didn't correspond to anything previously reported. Are these potentially of concern? In any event, the scientific and environmental community thinks that it is very important to sort out questions like this. If not these particular bryozoans, there are likely to be other groups of similarly cryptic organisms that do have rare enough species that Corps operations are likely to threaten them (and vice versa). Sorry for getting on my soapbox about this...

By-the-way, I (and surely the readers) would love to see a picture or graphic showing a typical example of these bryozoans attached to a shell fragment or sand grain. The point being that it is hard to otherwise appreciate how small, stealthy, and difficult to observe these creatures are.

My apologies for not including a picture. Because I was running behind your schedule and over budget (believe it or not, I/WES lost money on this project or at least subsidized it through "donated" time from other projects and uncompensated overtime), I wanted to get this off to you as soon as I could. In addition to photographs, I had hoped to have time to tidy the manuscript up a bit more. I did provide Bill Lang with a photo of one of the more common species – about the size of the eye on a Lincoln penny. I hope to get one or more photos off to you in the future, but it may be several weeks before this happens. The photographs (actually electron micrographs) in Judy Winston's publication are quite good.

I hope this addresses your questions. Please feel free to contact me about any other questions you may still have.

Best Regards,

Bill